
UNIT 9 SELECTION, PLANNING AND MATCHING OF CONSTRUCTION EQUIPMENT

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9.1 INTRODUCTION

As mentioned in Unit 8, each construction equipment is specifically designed by the manufacturer to perform certain mechanical operations and since every equipment has different operational characteristics, it is not always obvious which machine is the most suitable for a particular work. For example, what is less expensive to make an excavation with scrapers or to top-load trucks with a dragline ? Both equipment may yield same end result but which is the most economical proposition ?

To find the answer of this question, the planner draws an initial plan of employment of both the equipment. The planner also calculates both equipment's production rate and the associated resulting cost. Finally, the type of equipment having the lowest estimated total cost is selected for the task.

In this unit, you will learn about the various procedures for selecting, planning and matching of construction equipment.

Objectives

After studying this unit, you should be able to

- explain equipment selection, equipment planning, and matching of construction equipment and plant,
- describe the construction plant and job layout,
- discuss the various ways of financing of construction equipment,
- evaluate the hire-purchase options, and
- describe the owning and operating cost of equipment.

9.2 EQUIPMENT SELECTION

In Section 9.1, through an example, it has been tried to establish that certain factors govern the equipment selection for a particular job. Generally, following four factors are to be considered when an equipment is to be selected :

- (a) Equipment productivity, (b) Product features and attachments,
- (c) Supplier support, and (d) Cost.

These are discussed in subsequent paragraphs.

Equipment Productivity

In some types of operations, the production required is a known quantity. The best size of equipment can be chosen to deliver that production at the least cost. Quite often, determining equipment size is not so simple.

Past experience is a major factor to assess the size of equipment that will give the best production rate. The buyer's own experience can be supplemented by that of the equipment supplier. Many suppliers can furnish data on equipment capability under varying operating conditions.

Primary usage should be distinguished from secondary usage. Suppose a crawler tractor is under consideration. Is it being purchased primarily for bulldozing, land clearing, ripping, or push-loading scrapers? Primary usage is an important consideration in determining the size of equipment and its attachments, while some compromise can be made in secondary usage.

Equipment production is greatly affected by the operating conditions. Wheel tractor-scrappers are more productive on a flat, straight, well-maintained haul road than they are on an uphill, rough, winding road. They can be loaded faster with certain materials than with others. Some materials are difficult to eject and spread on the fill, while others can dump fast and clean. In assessing the equipment productivity, all conditions to be encountered in the work cycle should be considered.

Equipment rarely operate on conditions that are static or predictable. Experience and judgement can define them best. Experience is having a good understanding of the area in which the equipment will work. These include topography, soil types and climate. Judgement is the ability to evaluate possible combinations of operating conditions as actually existing. What will the equipment encounter, most of the time, during its productive life? Local equipment suppliers can help in evaluating local job conditions and the effect on the productivity of a specific equipment.

When considering larger equipment, transportability between work sites becomes an important consideration. Legal restrictions on the movement on highways should be determined. Whether special permits are needed or can the equipment be partially dismantled and reassembled in case of permits not being available, are some of the considerations.

In considering equipment size, the operator's wages is also a factor. As the size and productivity of an equipment increases, the operator's wages become a smaller percentage of the cost of moving a unit volume of material. But, an equipment that is too large can become an economic burden and an application handicap. Conversely, an equipment that is too small will probably require greater maintenance and repair.

Product Features and Attachments

Construction equipment are available with a wide variety of features and attachments that offer greater productivity, broader applications, increased operating safety, and improved operator convenience. These features should be properly evaluated. Will they improve the productivity of the equipment? Will they permit the equipment to work in an area that it would normally not be able to do? Are there necessary features to ensure proper safety to operators and other personnels?

Equipment productivity can be increased in many ways. Some of them are as follows :

- (a) By choosing the right equipment with the right attachments. For example, automatic bucket controls, special purpose buckets, and optional counterweights may increase production of wheel loader.
- (b) By reducing equipment downtime. The ability to diagnose and correct malfunctions quickly, or the ability to spot potential trouble during routine maintenance and correct it before expensive overhaul becomes necessary, will increase equipment availability.
- (c) By adding special attachments such as a retarder for speed control on grades, or special application cutting edges. It can enable an equipment to do work that ordinarily it would not be able to perform economically.

Safety features deserve particular attention. The safety of operator and other personnel is an equipment owner's responsibility which cannot be taken for granted. The availability of warning lights and indicators, windshield wipers, and seat belts should all be examined and evaluated.

Selecting tyres for wheel type equipment, and track for crawler equipment is a critical process. Special tyres are available for high speed hauling, for abrasive surfaces, or for work where quicksand condition is a problem. Track options are available for crawler tractors to meet a variety of special working conditions. Technical advice should be sought when unusual conditions are expected. Working together, the equipment supplier and the equipment owner can achieve the most economical answer to a specific tyre or track selection problem.

Experience, local regulations and practices, and factual cost and production records should enable the prospective buyer to make a good selection of equipment features and attachments.

Supplier Support

From the time of purchase to the final resale, the equipment supplier plays an important role in determining whether a particular equipment can become an efficient part of an economical earthmoving system.

The availability of spare parts, service facilities, and qualified personnel for training the operators must be considered. No equipment can work indefinitely. When it does require service, will there be trained personnel with the proper tools and plant to diagnose and correct the problem? Are spare parts available or will the equipment have to sit idle waiting for them? Can major assemblies be quickly and easily changed, and are replacement assemblies available on an exchange basis?

Supplier support can take many forms. Agreements are offered that support regular machine inspection, service, guaranteed availability, and predetermined prices when the equipment is returned for trade. Long- and short-term lease arrangements can be negotiated to guarantee availability, allow for purchase, or guarantee a total cost per equipment hour.

Cost

The cost of an equipment is the final factor for consideration. The cost of purchase should be just one part of the overall selection criteria; resale cost should also be considered, along with maintenance and repair costs. Although an equipment costs less initially, it may be more expensive during its working life. A low initial cost is a worthwhile consideration only when coupled with satisfactory performance and supplier support for parts and service.

All the factors should be considered and weighed to reach the best decision. The total cost of owning and operating a equipment, and not the equipment price, should be the deciding factor in equipment selection.

SAQ 1

- (a) What factors are to be considered in selecting construction equipment ?
- (b) What is the role of equipment productivity in selecting an equipment ?
- (c) How do product features and attachments affect the selection of an equipment ? Why is supplier support necessary in equipment selection ?
- (d) How can equipment productivity be improved ? What does cost have to do with the equipment selection ?

9.3 EQUIPMENT PLANNING

Equipment planning can be defined as making or arranging equipment for executing a project or program before the work being planned is underway. It goes beyond just deciding what work will be carried out the next day. It involves drawing up a detailed

plan of work cycles well in advance and providing equipment to meet the requirements of the production desired.

Developing an operational plan of action is the primary requirement in the process of scheduling any project. The project plan must clearly indicate what is to be achieved and depict the sequence or procedure and the methods to be used. This requires that the entire project work be described as simply as possible. Once the tasks have been identified it is then necessary to consider the equipment requirements for each task in developing the action plan. The process of planning involves decision making of how and in what order. Once that has been decided then the equipment, by class and number, are determined keeping the production rate to be achieved.

The equipment planning team should have detailed knowledge and experience in the work to be done and the kinds of equipment required to do it. The team must have authority for decision making commensurate with the high level of responsibility the planning of equipment involves. The planners must be skilled in the techniques to be used.

Here, the critical path method (CPM) of analysis comes handy. Once the network is developed, a time grid network is drawn and on it is marked the equipment required for the various activities. Histograms developed indicate the number and type of equipment and the time period for which required.

While planning equipment for a project, the equipment selected should be utilised for 75% of its economic life on the project. There is no need to procure the peak or maximum number of equipment right at the beginning. The work will go on at a slow pace at the start and then pick up momentum. As more and more activities are added on the project the progress on the particular item of work will slow down. Accordingly, less number of equipment are required in the beginning and as the work speeds more equipment of the same kind are added and when the work tempo reduces, the older machines should be discarded or moved to another project in a phased manner.

SAQ 2

- (a) What do you understand by equipment planning ?
- (b) What is the primary requirement of scheduling any project ?
- (c) How does equipment planning team decide the requirement of construction equipment ?
- (d) How are equipment procured and phased out on a project ?

9.4 MATCHING OF CONSTRUCTION EQUIPMENT AND PLANT

On any construction job a number of equipment and plant are employed for execution. They often work in combination to produce the end product.

Take the case of a concrete dam. The construction involves the production of aggregates, handling of ingredients such as cement, aggregates, water and admixtures, batching and mixing the concrete, handling of the mixed concrete which involves transportation and placement and compaction. Each of the items are performed by different equipment and plant. All the activities have to be performed at the same rate so that there is no stoppage of work for want of equipment or product of the previous operation. Thus matching of construction plant is essential. The crushed aggregates produced by the aggregate processing has to be handled by the belt conveyor system at the same rate. The batching and mixing plant which produces the mixed concrete should balance the aggregate processing and conveying plant. The transportation equipment be it flat body truck with concrete buckets, or agitator cars, bucket on cableway or dump trucks should match the mixers. The concrete vibrators should be adequate to compact the concrete as it is unloaded by the transportation equipment. Where cranes are needed to unload the buckets they should balance the transportation and compacting equipment.

Another case is excavation and transportation of earth by a combination of power shovels or draglines and carriage by dump trucks. The product of excavation of the shovel has to be handled efficiently by the carrier units.

In either case, the matching between equipment and plant is very essential. Even if any one plant or equipment is inefficient or unable to handle the product which it has to handle at the same rate as the previous operation the production of the entire process is sure to fall. This will lead to an increase in the cost of unit of production and in the project cost.

SAQ 3

Give an example of matching of construction equipment and plant.

9.5 CONSTRUCTION PLANT AND JOB LAYOUT

A job layout is prepared by the superintendent at the start of a project. On this layout, he draws to scale, the area available for offices, equipment, storage of materials and warehouses, construction forms and fabricating reinforcement and structural steel members. In preparing the site layout, all areas are arranged so as to reduce the time consumed in carrying materials from the storage area to the project and moving the equipment from the workshop to the site of work. Equipment and materials that are similar in use should be stored close together where possible. When storing cement the stacking of cement bags should be so made that the first bag in is the first to be taken out.

Materials handling or hoisting equipment has to perform a large variety of functions in building a dam, and the selected layout must be able to do all that is required of it. The functions include shifting formwork, welding sets, sand blasting equipment from block to block, reinforcement bars and testing equipment and so on.

It is desirable to make a layout which, as the work goes on, tends to systematise itself. It is a very expensive job to teach 2000 to 4000 persons about keeping their work going in the most economical way for the project as a whole. Where the equipment functions so as to permit everyone to become familiar with its purposes. There is a natural tendency of learning on the part of every man on the job and the job layout will teach a large number of persons within a short time.

Once the plant layout and the equipment are designed and selected, the entire job is practically fixed. If the plant and layout are right, the job is as good as done. But, if it is wrong, it costs more to change, as a general rule, than can be saved. Mistakes in any selection of plant or equipment not only retard construction progress in general but also lower the morale of the personnel on the entire project.

Quite often, a small model of a plant layout will serve as a valuable check of a paper study, or will often bring out elements that have previously been overlooked. Models of special equipment will provide valuable information and, in any case, reassurance before any large expenditures are made on full scale operation that the proposed scheme will work satisfactorily.

SAQ 4

- (a) How is the site layout of construction plant on a job prepared ?
- (b) What are the functions of hoisting equipment on a concrete dam ?
- (c) Why is a proper plant layout important ?
- (d) Discuss the use of models on plant layout and equipment design.

9.6 FINANCING

Construction equipment is the most vital part to perform any construction work. This requires financing so that the contractor can conserve his money and remain sufficiently fluid to manage his business and have cash reserves to take the advantage of contracting opportunities as they occur.

Equipment can be financed in many ways. Some of them are as follows :

- (a) Most equipment suppliers make financial arrangement available to the purchaser. After the required down payment is made (usually from 10 to 15% of the equipment cost), the balance can be paid off in monthly instalments. A note and a conditional sales contract is entered between the supplier and the buyer. It may be for the full amount of the purchase with a credit showing the amount of down payment, or simply the balance stating the monthly payments, which include the principal and the interest. The supplier retains ownership of the equipment till the last payment is made.

The interest rate is usually high, may be 50% higher than the supplier can obtain from his bank and sometimes may carry interest on the full value of the purchase until the entire purchase price is paid. This type of contract is very expensive and should be avoided at all costs because it charges interest on interest. If the buyer has any reasonable credit rating he can always insist on the interest being charged on a declining balance. The supplier often will decide to discount the note with his bank. In this case the contract will usually carry simple interest on a declining balance as payments are made.

- (b) Various commercial corporations finance construction equipment. These corporations do a professional job but usually charge high interest rates, always higher than the normal bank rate. If the buyer lacks a good credit rating, they are likely to charge full interest on the original sum till the loan is paid.

Although interest is an expense and can be taken as an income tax deduction, the deduction is of no use unless it can be charged against a profit.

- (c) A number of companies have been formed that buy equipment and lease it to the user on a term basis, and even some banks have divisions or separate companies that make this a practice. Under certain circumstances, this arrangement may be suitable, but it must be analysed carefully.
- (d) When the contractor has good bank credit and an adequate sum of money available, he may deal directly with the bank. To accomplish this, he places an "equipment note" with the bank. A number of items are listed in the note which includes the equipment being financed and the purchase price of each item. Since the buyer is going to pay the supplier in cash, he will be able to obtain a cash discount of about 10-15% off the list of the equipment price. In general, banks prefer to finance about 75% of the original cost. This leaves the buyer to finance the purchase to the extent of 25% from his resources. The terms of the loan are flexible both as to the interest and the repayment dates, the length varying with the expected life of the equipment. Heavy excavating equipment may be financed upto 4 years, heavy trucks and tractors upto 3 years, while trucks, compressors, concrete mixers for 2 or $2\frac{1}{2}$ years. Payments on the note are made monthly or quarterly. The bank is informed when the equipment is sold or moved outside the country and the bank is paid whatever amount remains unpaid.

SAQ 5

- (a) What do you understand by "financing of construction equipment" ?
- (b) In what ways can construction equipment be financed ?
- (c) Write short note on "equipment bank".

9.7 HIRE-PURCHASE OPTIONS

When the contractor must acquire additional equipment to carry out the work under the contract, he should decide whether

- (a) to purchase, or
- (b) take it on rent with option to purchase, or
- (c) to take it on rent without purchase option but under a lease agreement.

Under certain conditions it is financially beneficial to purchase, while under other conditions it is more economical and satisfactory to take it on rent. The method selected should be one that will provide the use of the equipment at the lowest total cost, consistent with the use that the contractor will make of the equipment. Each method has its own advantages and disadvantages which should be considered before making a decision. If cost is the only criterion, an analysis of the cost under each method should give the solution. If other factors are to be considered, they should be evaluated and applied to the cost as a basis on which to reach a decision. The appropriate decision for one contractor will not necessarily apply to another contractor. For instance, Contractor A may engage in a work that requires the use of a mobile crane for most of his jobs, while Contractor B may need the crane only once in 2 or 3 years. It is probable that Contractor A should purchase the crane while Contractor B should take it on hire. Thus a contractor should purchase equipment that he will use frequently while he should hire equipment that he will use only rarely.

The purchase of equipment, as compared to renting it, has many advantages :

- (a) It is more economical if the equipment is used sufficiently.
- (b) It is more likely to be available for use when necessary.
- (c) Because ownership should assure better maintenance and care, purchased equipment should be kept in better mechanical condition.

The following are the disadvantages of purchasing and owning equipment :

- (a) It may be more expensive than hiring.
- (b) The purchase of the equipment may require a considerable investment of money that may be needed for other purposes.
- (c) The ownership of equipment may influence a contractor to continue to use obsolete equipment even after superior equipment has been introduced and available in the market.
- (d) The ownership of equipment designed primarily for a given type of work may induce a contractor to continue doing that type of work, whereas other work requiring different types of equipment might be available at higher profit.
- (e) The ownership of equipment might influence a contractor to continue using the equipment beyond its economic life, thereby increasing the cost of production.

The most important factor in deciding whether to purchase or hire it is its expected long term utilization. Renters of equipment charge a profit, and thus their hourly rate would be higher than the comparable cost to the owner, if he used the equipment extensively. If the expected use is for a short period, then renting it is usually the cheaper.

Once the decision is taken to purchase or rent, the next decision to be made is whether to simply rent the equipment or rent the equipment with the option to purchase it. The second alternative will result in a higher rental cost as some of the periodic rental charges will be applicable toward the purchase price of the equipment. This is an attractive alternative if the person taking the equipment on rent believes he may have enough use for the equipment to purchase it, but is not too sure that the utilization will be as high as predicted. Such rental agreements result in higher hourly charges than simple rental agreements.

SAQ 6

- (a) What are the hire-purchase options available to a contractor ?
- (b) On what conditions should equipment be purchased ?
- (c) On what conditions should equipment be taken on rent with the option to purchase ?

- (d) Discuss the conditions under which the equipment should be taken on rent under a lease agreement ?
- (e) What are the advantages of purchasing equipment as compared to renting it ?
- (f) What are the disadvantages of purchasing equipment as compared to renting it ?

9.8 OWNING AND OPERATING COST

There are several methods of determining the probable cost of owning and operating construction equipment. No method will give the exact costs under all operating conditions. At best the estimate is only a close approximation of the expenses. Records of previously used equipment should provide information that may be used for the particular equipment. However, there is no assurance that similar equipment will involve similar costs, particularly if the equipment is used under varying conditions. Factors that affect the cost of owning and operating construction equipment include the cost of the equipment delivered to the owner, the severity of job conditions, the number of working hours in a year, the number of years the equipment is used, the care with which the owner maintains and repairs it, and the demand for used equipment when it is disposed off, which will affect the salvage value.

When the cost of owning and operating of construction equipment is to be estimated before it is purchased, the cost records based on past experience, will generally not be available. The costs which should be considered include capital investment and depreciation (i.e. the ownership costs) maintenance, repairs, petrol, oil, and lubrication charges (i.e. the operating costs).

SAQ 7

- (a) Differentiate between owning and operating cost with the help of a suitable example.
- (b) What factors affect the cost of the owning and operating construction equipment ?

9.9 SUMMARY

In this unit, you learnt about the various considerations affecting the construction equipment selecting. They are equipment productivity, product features and attachments, supplier support and cost.

Equipment planning being a very important activity in equipment management, it covers the development of an operational plan of action keeping in mind the primary requirements in the process of scheduling any project.

On any construction job, a number of equipment and plant are employed for execution. They often work in combination to produce the end product. The matching of these construction equipment and plants with respect to their productivity rate and involved economics is very essential for optimal utilisation of these equipment and plants.

In the beginning of any project, a job layout is prepared. On this layout, various areas available for offices, equipment, storage of materials and warehouses, housing structural steel members are shown to some suitable scale. Once the right plant layout and the equipment are designed and selected, the job is practically fixed.

Since the construction equipment form the most vital part to undertake any construction assignment, many a times, it requires financing from external agency to keep necessary

cash reserves with the contractors to take advantage of other contracting opportunities. The unit gives description of some sources through which the equipment can be financed.

Finally, the unit deals with the economic trade-off of hire-purchase situation to procure the necessary equipment and presents a brief description of owning and operating costs associated with any construction site.

9.10 KEY WORDS

Construction Plant and Job Layout	: The manner in which construction plant arranged on a project.
Equipment Planning	: The manner in which construction equipment are obtained for executing a project.
Equipment Selection	: The manner in which construction machines are chosen for executing a job.
Financing	: Obtaining funds for procurement of equipment.
Hire-purchase Options	: The choices available with regard to equipment procurement.
Matching of Construction Equipment and Plant	: The manner of selecting a combination of equipment and plant to do a particular job.
Owning and Operating Cost	: The costs involved in the use of construction equipment on a job.

9.11 ANSWERS TO SAQs

Refer the relevant preceding text in the unit or other useful books on the topics listed in the section "Further Reading" given at the end of the block to get the answers of the self-assessment questions.